

A Case Study of the Barriers to Eradicating Polio in Nigeria and India's Urban and Rural Settings

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In this study, we examined polio eradication efforts in the urban and rural areas of Nigeria and India. Our method utilized past literature and databases to support our comparison of the different issues Nigeria and India had with distributing the oral polio vaccine (OPV). The data showed that Nigeria had issues with political and social misconceptions about the OPV in both urban and rural areas while India had technical issues with vaccine distribution. Therefore, it was necessary for the Global Polio Eradication Initiative to implement polio campaigns, reorganize their plan in vaccine distribution, and provide more vaccines to children in isolated areas where there is poor medical infrastructure in both Nigeria and India. We conclude that there needs to be a greater cultural understanding among vaccine distributors and improvements to the vaccine distribution technology in Nigeria and India.

Keywords

Vaccinations • polio • cold chain development • India • Nigeria • socio-economic development

Introduction

The polioviruses, *poliomyelitis*, are enteroviruses, a group of viruses that develops in the gastrointestinal areas of the human body and sometimes can impact the nervous system. Polio is transmitted through person-to-person contact via hand-to-hand-to-mouth and can follow with the excretion of feces (Nathanson & Kew, 2010, p. 1213). The Salk polio vaccine was introduced in 1955 (Nathanson & Kew, 2010, p. 1219). Jonas Salk was the first to develop an inactivated polio vaccine (IPV) using monkey kidney cells (Baicus, 2012). While the IPV was effective, there were

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some disadvantages to the vaccine, including the inefficiency of producing and distributing the vaccine (Baicus, 2012). The oral polio vaccine (OPV) was launched in 1961 by Albert Sabin with a higher success rate (Nathanson & Kew, 2010, p. 1219).

In response to the polio epidemic, the Global Polio Eradication Initiative (GPEI) became the main player in eradicating polio worldwide. As a public–private partnership, the initiative worked with the World Health Organization (WHO), Rotary International, the United States Centers for Disease Control and Prevention (CDC), the United Nations Children’s Fund (UNICEF), Bill and Melinda Gates Foundation, and Gavi (Global Polio Eradication Initiative, 2020). Based on the GPEI, polio was eradicated in Nigeria in 2016 and in India in 2014 (Global Polio Eradication Initiative, 2020). The increased political support, expansion to children in isolated areas, and reevaluation of India’s and Nigeria’s eradication plan all contributed to the final success in eradicating polio in the twenty-first century (Aylward & Tangermann, 2011).

The purpose of this article is to analyze how polio eradication in the 1990s–2010s failed to succeed in Nigeria and India based on private and public interventions within rural and urban areas in both countries. The article will also provide a case study on these two countries to analyze the multiple stakeholders that influenced the barriers in distributing the polio vaccine among rural and urban areas within Nigeria and India. The journal articles mentioned in this literature review will attempt to support our analysis and case studies.

Review of the Literature

Although the polio vaccine was developed successfully in the 1950s, there were many issues with the distribution of the polio vaccine in many lower- to lower-middle-income countries. Factors including high incidences of vaccine failures, high incidences of polio from the OPV, the lack of availability of the IPV, and ethical issues with the distribution of vaccines in many countries all contributed to the multiple inefficiencies of polio eradication (Thomas, 2005). Countries like Nigeria, India, and many others were unable to gain access to the polio vaccine through barriers from the political environment, the lack of social mobilization and community intervention, and the lack of knowledge around vaccines (Lahariya, 2007).

Nigeria’s Urban Setting

Taylor et al.’s research (2017) was trying to understand vaccine hesitancy among different demographics within Nigeria. The study surveyed 3,306 male and female individuals within 1,653 households from rural, semi-urban, and urban areas that were identified as either high- or low-performing areas. The study focused on three high-risk states in northern Nigeria from 2013 to 2014. Questions from the survey concerned household socioeconomic status, family health conditions and access to resources, household and community development, and level of knowledge in polio vaccination. Due to the high refusal rate of the OPV in Nigeria overall, the researchers tried to hypothesize why there was vaccine hesitancy based on how certain backgrounds and demographics influence health behavior. The authors discovered that wealthier households and higher female literacy rates were in correlation with a lower risk of OPV refusal. However, in urban areas, they found that higher levels of wealth and education correlated with having a higher risk of OPV refusals. The results of the study support the purpose of our research in which it distinguishes the many demographics and

how they factor into the refusal rate for the polio vaccine. Taylor et al.'s research connects to the overall aspect of how the polio vaccine was distributed among urban areas in Nigeria, and based on their results, we can conclude that it was also very challenging for the GPEI as well as private and public institutions within Nigeria to integrate the polio vaccine within urban settings.

From Maryam Yahya's perspective (2007), one of the major barriers to polio eradication in northern Nigeria was the political and cultural views on the vaccine. Yahya analyzed how much of the rejection of the vaccine came from political and cultural influence. Many political and religious leaders spread misinformation and rumors about the vaccine's safety, thus creating fear among certain communities and individuals. Rumors about the vaccine included how the vaccine can harm their children and how "white men" created the vaccine to poison Nigerians. On the other hand, Yahya also described how family dynamics in a Nigerian household can also play in getting a vaccine. According to Yahya, due to the cultural norm of the husbands usually making final decisions in the household, many fathers have the authority to determine whether their children get vaccinated or not. Yahya addressed that the fear of the vaccine mainly stems from a lack of education, literacy, and ignorance. The author later concluded that the failure of polio eradication in northern Nigeria came from the lack of basic primary healthcare provision and the weak relationship of trust between the Nigerian government and Western countries and influence. This study can be used to interpret how condensed populations in urban areas are heavily affected by poliovirus due to many households not getting vaccinated based on their personal beliefs and the spread of misinformation.

A final research article was examining how the diplomacy and the boycott on polio eradication in northern Nigeria created a health crisis with the poliovirus in the country (Kaufman & Feldbaum, 2009). Judith R. Kaufman and Harley Feldbaum explained the diplomatic actions taken by the GPEI, the United Nations, and the U.S. government to resolve the issue of rejecting the polio vaccine in Nigeria. The authors described the situation in Kano, where the boycott was held, and then illustrated how outside third parties responded to resolve the health crisis using a case study. The article concluded how using diplomatic actions was better to resolve the political issue within Nigeria. It also stated how there is a need to acknowledge the political issues in science as well as provide accurate scientific information on the vaccine to integrate polio eradication in such lower-middle-income countries where there is a lot of stigma around outside interventions. The authors further emphasized the need to intervene not only on a policy level but also using local and community-based interventions to spread accurate information about the vaccine.

The aforementioned studies provide information on how different determinants influence health behavior in terms of polio eradication in Nigeria. These studies will provide us with historical background and analysis on how polio eradication was resolved and implemented in Nigeria's urban cities. Based on the information we have, this will be helpful for our case study when we examine the differences in how Nigeria and India handled the polio vaccine.

Nigeria's Rural Setting

The obstacles and methods of the distribution of the polio vaccine in rural Nigeria are not very well researched; actions and research done by Samuel Bawa et al. (2018) discuss the obstacles and solutions to vaccinating children in hard-to-reach areas within Nigeria. The research group conducted vaccination trials in 2,311 hard-to-reach areas in the Bauchi, Borno, Kano, and Yobe states

in North-East Nigeria. Research done by Ophori, Tula, Azih, Okojie, and Ikpo (2014) can corroborate the arguments by Bawa et al. by providing evidence in current trends of the polio vaccine within different states in Nigeria, as well as by going into further detail about the obstacles in the way of mobile vaccination teams. A third study by Ghinai, Willott, Dadari, and Larson discusses the major obstacles in the distribution of the polio vaccine in North-East Nigeria. The most important aspect of this study is its methods of collecting information through local rumors and information. Local information provides a broader understanding of intra-country affairs that would not normally be available. While these studies mainly focus on the North-East states of Nigeria, it is important to note that a majority of rural areas, and therefore hard-to-reach rural areas, are in the South of Nigeria. This drawback of these studies makes it difficult to differentiate between the methods used in distributing the polio vaccine between rural and urban settings.

A final research study was done by Abimola, Malik, and Mansoor (2013); they discussed the obstacles that got in the way of distributing vaccines to Nigeria. The religious divide between the North and the South of Nigeria creates a large division between cultures and people, as well as a distrust of the government by the North. The research group also identifies Islamic extremist groups like Boko Haram as creating political instability through political violence, predation on citizens, and anti-education. The research into these obstacles can help further corroborate the troubles that the GPEI, as well as the Nigerian government, has in distributing the vaccines, shown by Bawa et al. and Bauchi et al.

India's Urban Setting

India did initially manufacture the polio vaccine within its borders, yet this was discontinued in 1974. From that point on, the OPV was imported from abroad and distributed to strictly urban communities until 1981. Vaccinating those who lived in larger cities was first prioritized, primarily due to the ease of access. These urban areas struggled with the virus mainly due to cramped conditions—a symptom of India's vast population—minimal public healthcare, and extremely poor sanitation (Thacker, Vashishtha, & Thacker, 2016). There have been studies comparing the incidence of polio within the urban and rural populations of individual cities, such as Lucknow, India (Chaturvedi et al., 1978). The northern regions of Uttar Pradesh and Bihar are most frequently used as cases for these kinds of studies, primarily because efforts to eradicate polio were especially high in those places.

However, there is very little research done on the difference between polio eradication between the rural and urban areas in India. The main distinctions are made among the regions, but the locations of their populations are not specified. This provides ample opportunity for us to create this divide in our research and determine whether urban or rural Indians received quicker and more reliable access to the vaccine, and how that affected the country's overall progress toward eradication.

India's Rural Setting

Few research papers have looked into the difficulties of distributing the polio vaccine, as well as vaccines more generally, in the rural areas of India. Bonu et al. (2003) examined representative samples from four rural areas of Northern India, comparing using National Family Health Surveys from

1992–93 to 1998–99 as before and after samples, respectively, in order to determine the success of the national polio immunization campaign, Pulse Polio Initiative (PPI) (2003). The study concluded that while the PPI was successful in reducing gender-, caste-, and wealth-based inequalities, it did not have an impact on religion- and region-based inequalities. The researchers also found that the PPI campaign, which was applied to the first round of polio vaccines, increased immunization rates of children living in rural areas of India by 25%. The second round of vaccinations, which were not administered by the PPI campaign, only saw increases in immunization of 2%.

Research conducted by Samant et al. (2007) discusses that even the best vaccines are limited by distribution complications. If vaccines are exposed to high temperatures, they can lose their potency (2012). In areas such as rural India, access to refrigerators and coolers to store vaccines is limited, meaning that the vaccine's effectiveness diminishes as they are moved from larger medical centers to smaller centers. By focusing on one rural district of central India, these researchers studied the "cold chain" (meaning the system of storage and transportation that are designed to keep the vaccines at the correct temperature until they can be administered) as the vaccine moved from urban to rural areas. This study found that as the distance from the district hospital increased, the cold-chain compliance score—which measures the degree to which vaccine storage protocols are being upheld—decreased by an average of 0.16 units per kilometer. However, this study is limited by its scope as it only looked at one district of rural India. This study also did not test the potency of the vaccine, meaning that the study looked at protocol compliance and not necessarily efficacy.

A final study by researchers with the RAND Corporation can help contextualize the findings of Samant et al. (2007) and Bonu et al (2003). This study looked at 43,416 children living in rural India during 1993 and 1998 (Datar, Mukherji, & Sood, 2007). The study found that the availability of health infrastructure in rural areas only had a modest effect on immunization coverage. Furthermore, they found that having community health workers in a village did not increase immunization coverage. Their research concluded that having a hospital or primary healthcare facility near a rural village resulted in higher immunization coverage than lower-level facilities like subcenters or dispensaries. This correlation is associated with having more access to the cold chain of vaccines. They also found that literacy among mothers and whether or not the child belonged to a scheduled caste/tribe household also affected immunization coverage. Altogether, this study concluded that improvements in community outreach, increased funding to auxiliary nurse midwives, and female literacy programs will be the most effective measures to increase immunization coverage in rural India.

Methodology

We developed a case study on how the polio vaccine was eradicated in rural and urban areas in two countries: India and Nigeria. These countries were specifically chosen for this research because Nigeria and India were among the last few countries that still considered the poliovirus as endemic, and both countries encountered many different barriers while obtaining the polio vaccine. It was also important for us to look into different regions within India and Nigeria, so we examined urban and rural regions in both Nigeria and India to analyze how different demographics factor into the distribution of the vaccine within these communities. We looked specifically at urban and rural areas to factor in disparities among geographical areas that helped us interpret our case study. Our

independent variables were India's and Nigeria's key effects on polio eradication and our dependent variable was the timeline and efficiency of polio eradication in both countries. The main key effect in India was the technological costs related to the transportation of vaccines. On the other hand, the key effect in Nigeria was misconceptions about the OPV.

To gain a better understanding of the barriers to eradication in Nigeria, we segmented our research into the politics and religious beliefs in rural and urban areas. We utilized databases and news articles throughout the 1990s to understand how the spread of rumors about the vaccine restricted people from obtaining it, how the government became involved in preventing the vaccine from distributing within the country, as well as how data on the number of vaccines distributed within both urban and rural communities helped interpret the challenges of integrating polio eradication in Nigeria. Additionally, we examined the barriers to transporting the polio vaccine in rural and urban India. More specifically, we looked at how effective compatible cold-chain implementations were in maintaining the potency of the polio vaccine in India, and how this barrier affected rural areas only.

Because our research has more of a qualitative approach, we utilized data from past research on polio eradication in Nigeria and India, ranging from different costs and challenges to how the government influenced the entry of the polio vaccine in both countries. With the existing literature, we used these studies to investigate key issues on the different approaches from each country and to apply theoretical ideas and methods to create a more comprehensive and successful approach to polio eradication within Nigeria and India.

Results and Findings

Nigeria

Although polio cases worldwide have declined around the early 2000s due to the introduction of the OPV and the launch of the GPEI in 1988, Nigeria had been facing a surge in cases with polio becoming endemic in the country until the beginning of 2013 when vaccine coverage increased to 60% (Abimbola, Malik, & Mansoor, 2013). The number of wild poliovirus cases jumped from 62 in 2011 to 122 cases in 2012 after immunization activities in Nigeria were suspended (Lowther et al., 2013). The barriers around polio eradication in Nigeria were based not on the lack of technology to distribute the vaccine but rather on the political and cultural beliefs around the vaccine. With vaccine boycotts and rumors going about the vaccine, there became a major rejection of the polio vaccine, thus creating a surge in cases in Nigeria in the early 2000s (Kapp, 2003). The number of wild poliovirus cases increased from 202 in 2002 to 355 in 2003, which then created a high alert in the WHO and GPEI (CDC, 2004). The halt of polio campaigns and immunization programs in northern Nigeria jeopardized the WHO's 15 years of work put into the Polio Eradication Initiative and the United States' \$3 billion in funds for developing the vaccine (Kapp, 2003).

In August 2003, northern Nigeria, especially the Kano State, suspended the polio vaccine in response to misinformation on how the vaccine was contaminated. Much information was construed to antifertility, describing how the vaccine was intended to sterilize young Muslim women (Kaufmann & Feldbaum, 2009). However, more hesitancy was based on past failures of vaccine trials. Pfizer implemented the drug Trovan into the Kano State to help with the meningitis outbreak in 1996 (Frishman, 2009). During their drug trial, Trovan was given to 100 children, and

another 100 children were given chloramphenicol. As a result, 11 of the children died due to the implications of Trovan and chloramphenicol. Others suffered from severe health outcomes such as paralysis, blindness, and brain damage (Frishman, 2009). A Nigerian report later revealed the outcomes of the drug trial in 2000, which led to demands in compensation for damages toward Pfizer (Frishman, 2009). Thus, the skepticism, rumors about the polio vaccine, and past failures of drug trials that occurred in Nigeria have led many Nigerians to reject the polio vaccine.

Urban Setting

Much of the misinformation and hesitation of the polio vaccine can be applied to urban areas in Nigeria. While urban areas are more affluent and many residents in urban settings are more likely to get vaccinated, there is still much avoidance of the polio vaccine. Such skepticism revolves around the Western influence that involves many Nigerians believing how the vaccine is there to harm them instead of protecting them from the poliovirus (Renne, 2006). Much propaganda in Nigeria is based on Western influence trying to destroy Nigeria's Muslim population through sterilization and vaccine campaigns (Abimbola et al., 2013). For instance, Zaria City, a city in northern Nigeria that has well-established academic institutions and hospitals, had many suspicions around the safety of the OPV. Many parents are not allowing their children to get vaccinated due to much distrust in Western interventions and the Nigerian government. Since the OPV has four doses, only 15% of the 339 children in Renne's experiment finished the entire process, which overall has led to lower rates of completed polio vaccination in Zaria City (Renne, 2006).

Despite the advancement in urban areas in education and wealth, much of the hesitancy and refusal of the polio vaccine in urban areas still came from high expectations of government services that were not met by the Nigerian government. People who expected the government to provide more information and distribution of the OPV had higher rates of refusing the vaccine (Taylor et al., 2017). Since urban households with higher education levels and more wealth had higher risks of refusing the OPV than in rural settings, the negative political views on both the local and national government as well as polarized views on Western intervention in Nigeria have led to a lack of success in eradicating polio in urban areas (Taylor et al., 2017). Furthermore, the communal aspect had a huge impact on the rapid spread of misinformation in regard to the OPV. This illustrates how the rapid spread of information formed a common mistrust toward the government, further creating a challenge to convince urban residents in getting a polio vaccine.

Because urban areas in Nigeria have residents who have higher education and high literacy rates, there seems to be a correlation between systemic problems and polio vaccine rates. Much of the rural areas in Nigeria have weak academic infrastructure, creating disparities in literacy rates between rural and urban areas. Overall, Nigeria has a literacy rate of 56.9%, with urban regions having a literacy rate of 74.6% and rural regions having a literacy rate of 48.7% (Olojede, Adegunle & Samuel, 2013). Families who have higher literacy rates are more likely to have their children vaccinated (Renne, 2006). Higher income also results in a higher chance of obtaining the polio vaccine. Only 4.3% of children did not get the vaccine in the highest wealth quintile and 36.1% of children did not get the vaccine in the lowest wealth quintile in Zaria City (Renne, 2006). Although there has been a strong correlation between higher education levels and a higher likelihood of getting vaccinated, there seems to be little connection in urban areas. Many parents did not feel obligated to vaccinate their children due to negative news and information given through news sources and mass media (Itimi, Dienye, & Ordinioha, 2012). Immunization was more common in rural areas than

in urban areas in southern Nigeria due to the lack of encouragement of vaccination through public health interventions as well as the rapid spread of negative outcomes of immunization through mass media, deterring many parents to vaccinate their children (Itimi et al., 2012). Based on the mistrust in the Nigerian government and Western influence, much of the refusal of the OPV comes from political agitation and skepticism about the government instead of the correlation between education and income; this indicates that even in urban areas, there has been much conflict in the benefits and doubts about the OPV. Therefore, there are much more overpowering factors such as the tendency to believe propaganda and misinformation than just higher levels of socioeconomic status that determine the high rates of OPV refusals in urban settings.

Because of the many cultural differences and misinformation about the polio vaccine, the GPEI needed to tackle the situation in a more efficient way that tailored toward many Nigerians. The lessons learned mainly referred to educating communities on the importance of immunization through marketing strategies such as hanging posters, visiting schools, and getting religious and political leaders to promote the vaccine (Larson & Ghinai, 2011). (Larson & Ghinai, 2011). The GPEI used mass media such as radio stations, posters, and street banners in their favor to get the importance of immunization around to get people who were more resistant to getting the vaccine (Larson & Ghinai, 2011). The goal was to reduce the false information from spreading more as well as breaking the conspiracy theories entirely through community engagement, proving to the public that much of the information was factually wrong (Abimbola, 2014).

Rural Setting

Similar to the urban areas, the rural areas of Nigeria provided obstacles in the distribution of the polio vaccine in terms of skepticism. Rumors apart from birth control being added to the OPV associating it with fears of cancer and HIV caused periodic cases of vaccine refusal and polio outbreaks (Ghinai, Willott, Dadri, & Larson, 2013). The roots of such conflicts and rumors are derived from regional rivalries between the North, East, and West since independence over disagreements on the national census results, civil war, religious clashes, and Islamic revivalism. These conflicts sparked rumors that the polio campaign was part of a Western agenda to reduce Muslim communities (Yahya, 2007). These rumors extended to donor-based aid as common thought process by Nigerian religious and medical leaders was that “the West” was fighting against the Middle Eastern Muslim countries and therefore were fighting against the Muslim world (Yahya, 2007). These instances in the majority rural state of Kano were highly similar to those involved in urbanized locales. Dissimilar to urban areas, however, was the prominence of local healers as an obstacle to the distribution of the polio vaccine. There were clashes between local definitions of polio, often referred to as “Shan-inna” in the Hausa community, and the biomedical definition of polio. These differences as well as the heritage of shaman-like healers gave further rise to the boycott of the polio vaccine (Yahya, 2007). The healer’s influence within local communities provided a significant obstacle that large-scale foreign aid organizations cannot get past and only further drives religious-based obstacles in the distribution of the polio vaccine.

Further beyond the anti-Western sentiment in Nigeria was the Islamist regime of the Boko Haram group that created political and structural obstacles to getting the vaccine to hard-to-reach areas. Militants created an incursion against health workers not only by physically blocking infrastructure and launching attacks on aid groups but also by further exacerbating the anti-Western thought that led to the polio vaccine boycott (Abimbola, Malik, & Mansoor, 2013). In 2014–2015,

the Global Vaccine Action Plan (GVAP) attempted to reach “2311 preselected, non-urban, hard-to-reach and underserved communities” in the states of Bauchi, Borno, Kano, and Yobe (Bawa et al., 2018). Through direct mobile outreach programs and teams, GVAP was able to increase coverage of supplemental OPV doses in children up to 5 years old (Bawa et al., 2018). The lack of medical infrastructure in these hard-to-reach wards limits vaccine distribution, and combined with internal conflicts, vertical intervention becomes difficult to achieve (Ophori et al., 2014). GVAP efforts as a horizontal, patient-focused intervention are more effective as it can circumvent socioeconomic issues such as misperceptions of routine immunization by local medical health professionals, the influence of religion by local health professionals, and inadequate cold-chain equipment to transport the vaccine by local agencies (Ophori et al., 2014).

Through this circumvention by horizontal intervention, OPV distribution rose by an average of 34% among children up to the age of 5. In a breakdown of specific age groups, vaccination rates of children under 1 year of age increased by 38%, from 23% at the start of the trials to 61% at the end. OPV rates of children from ages 1 to 5 increased by 30%, from 60% at the start of the trials to 90% at the end of the trials (Bawa et al., 2018). Horizontal integration helps pick up the “low-hanging fruit” that many foreign aid organizations ignore in their large-scale planning efforts. The horizontal integration approach also helps to bypass political conflicts within the country, such as Nigeria’s issue of religious warfare and militant groups as well as corruption in the executive. According to the data collected by GVAP, this method is seemingly more effective than large-scale aid projects. Therefore, in rural settings, the greatest threat to polio eradication were not the obstacles of anti-Western sentiment but political and socioeconomic issues.

India

Due mainly to its population size, India struggled with combatting the incidence of polio for a long time and only began successfully vaccinating its citizens around the early 1990s—thanks to the combination of involvement from trusted, internal professionals as well as external international organizations (John & Vashishtha, 2013). Only after the implementation of the WHO and Indian government’s National Polio Surveillance Project (NPSP) in 1997—which introduced heavy surveillance and national immunization days—was India able to make considerable progress and steered itself onto a sustainable track of herd immunity, rather than temporary resistance (Schaffer, 2012). Eradication did differ between rural and urban centers to an extent, mainly due to vaccine transportation costs associated with the former areas and population congestion in the latter.

Urban Setting

Urban communities in India tended to be the first to receive polio treatment, yet these patterns did vary from region to region. Overall, much of the concern with urban populations was the issue of overcrowding. Since polio is most commonly spread through fecal matter, improper sanitation systems and the close proximity of people in city centers created the perfect environment for the disease to become endemic (Chaturvedi et al., 1978). An additional concern for urban centers specifically was the travel of workers to and from urban and rural settings. It was not uncommon for people to work in urban areas, but then return to their rural homes afterward, which exacerbated the issue of polio spreading as they brought the disease back with them to these communities (CDC, 2011). Since these hubs were hotspots for disease transmission, quite a bit of focus was

placed on urban areas at first, as opposed to rural ones. For example, specific wastewater testing for all three strands of the poliovirus was introduced in Mumbai in 2001, while subsequent cities like New Delhi or Patna received this treatment later on, in 2010 and 2011, respectively (CDC, 2011). However, although efforts were made to increase the sanitation quality of these cities, a major issue India faced was the dissemination of true information regarding polio vaccination of children. Many Indian families simply did not understand the value of vaccinating their children or were subject to misinformation of its side effects, as was the case in Aligarh—one of the largest sources of polio in the country (Hussain, McGarvey, Shahab, & Fruzzetti, 2012).

The main source of success for the eradication campaign in urban centers was thus linked to bridging these information gaps and intense documentation campaigns, led by both national and international vaccination teams—most notably Rotary International. In the early 1990s—when the strategy for targeting polio changed considerably—urban centers were the first areas of focus. For example, a pilot polio immunization campaign—the precedent to the NPSP—was conducted in Delhi at first (John & Vashishtha, 2013). Bringing together specialized teams to collaborate with trusted local leaders, organize an array of annual immunization days, and maintain vaccination records was the primary reason why India managed to eradicate polio by the mid-twenty-first century (Schaffer, 2012). Therefore, the methodological approach to this issue was functional and produced desirable results, while the sheer number of people in India was what prolonged the process.

Rural Setting

Throughout the process of distributing vaccines in the rural areas of India, several programs were implemented. In 1995, the PPI was carried out as a means of distributing the polio vaccine to children under the age of 5. Using the years 1993 and 1999 as pre-intervention measures and post-intervention measures respectively, researchers Bonu, Rani, and Baker found that child immunization increased from 48% to 73%. In determining gender-based differences between immunizations, the researchers concluded that male children were significantly more likely than female children to receive vaccines (Bonu et al., 2003). The data also showed that wealth-based inequalities worsened with the introduction of the PPI. A study by the RAND Corporation came to similar conclusions regarding immunization programs in rural India (Datar et al., 2007). This study found that having community health workers in a village did not result in higher immunization coverage. Furthermore, this study found that having a hospital or primary healthcare facility near a rural village resulted in higher immunization coverage.

The effectiveness and availability of technology for transporting vaccines have been looked at by several studies. The National Immunization Programme of India found that only 58% of subcenters had coolers, also known as vaccine carriers. Moreover, cold-chain equipment was underprovided. Out of the 75,000 proposed units of ice-lined refrigerators, only 2,876 were available; 250,000 vaccine carriers were proposed to be given out to subcenters, but only 35,500 units were available. This study also noted that the potency of the OPV was only accepted in 63% of India's stock when measured in 1988 (Bachani & Bansal, 1990).

A study on the availability of cold-chain equipment in a rural district of India found that cold chain compliance averaged 60% across 46 facilities. As the distance between the community health center or a sub-health center from the district hospital increased, on average the cold-chain compliance score decreased (Samant et al., 2007).

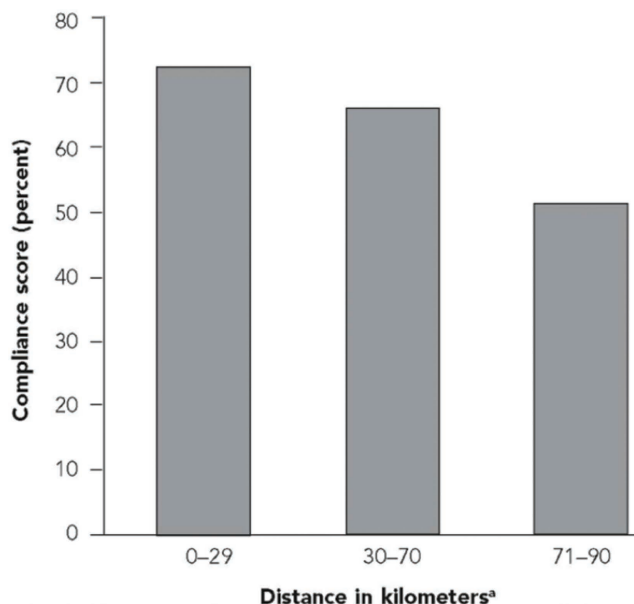


Figure 1. Comparison of compliance score and distance (Samant et al., 2007).

Samant et al. found that when a vaccine is not kept in a well-maintained cold chain, the vaccine's potency will decrease. This study found that cold-chain compliance decreased as distance increased, by an average of 0.16 units in compliance per kilometer (Samant et al., 2007).

Discussion

Based on our results and findings, we hypothesize that the major barrier in polio eradication in Nigeria was from the misinformation spread through word-of-mouth and propaganda in mass media and the government, which thus created much reluctance in getting vaccinated. This led to many issues in both urban and rural areas due to many negative beliefs and conspiracy theories about how the polio vaccine was developed to sterilize young girls and how much Americans were there to attack Nigerians through the vaccine. Overall, the GPEI had more of an issue in eradicating polio through a cultural lens in Nigeria than through the technology issues itself. Much of the cultural barriers and the rejection of the vaccine thus created a spike in cases in the early 2000s. Through our results, we also found that education and income played a factor in the risk of not getting vaccinated, but in urban settings, it was more about the massive and rapid spread of the negative information about the OPV that impacted the public more than their individual knowledge about immunization.

Additionally, we also discovered that many rural areas were more likely to become inoculated because they did not have advanced infrastructure, including roads to rural areas, to produce and distribute the OPV. The lack of medical resources and services capable of distributing the OPV became a huge challenge in needing to develop a more horizontal public health intervention than a vertical one to accordingly create a more efficient outcome from the GVAP. The horizontal intervention was to not only focus on eradicating the poliovirus but also improve the medical infrastructure in rural areas, integrate a vaccination plan that tried to gain more trust in the community, and develop a better plan in getting the OPV to the communities that are most at risk with the poliovirus.

In comparison to urban cities in India, Nigeria and India had many similar challenges regarding polio eradication. Much of the resistance came from misinformation and false beliefs about the effects of the vaccine, which led to many households rejecting any vaccination for their children. In India specifically, the lack of information regarding the proper application of the vaccination for households was an additional barrier to efficient immunization. With many urban areas having more of a condensed population, it was much more likely for residents to have poorer sanitation systems, have a higher risk of obtaining the virus, and be more susceptible to receiving wrong information about the vaccine through word-of-mouth and mass media. Therefore, much of the interventions through GPEI were focused on getting the right information and facts to these urban communities to break the common belief and theories about the vaccine. Successful practices included having internal and external third parties collaborate with local leaders to spread the correct information to increase the numbers of people who were vaccinated, as well as guide them in the application process. However, a difference in implementing public health strategies in urban settings in Nigeria and India was that religion was a major influence in Nigeria. Since Nigeria has a major Muslim population, religious and mosques were also utilized to spread information on immunization and polio vaccination in urban settings. Furthermore, India utilized more international organizations that were involved in polio vaccine campaigns, such as Rotary International, to promote the vaccination practices, while the GPEI was the major third party in trying to eradicate polio in Nigeria. Governmental initiatives, like the NPSP, were key in India's massive success as they united the eradication campaigns into one collective effort and ensured that all the vaccinations were properly documented.

The main difference in the treatment of rural and urban areas in India was the issue of distribution. Since the vaccines were developed in or delivered to the urban hubs directly, safe transportation was not necessarily a barrier to treating urban populations. For the rural regions, on the other hand, methods like cold-chain equipment had to be developed, tested, and improved to ensure that children there were being properly immunized. Community health workers and local leaders were efficient ways to both persuade Indians living in urban areas to utilize the vaccinations and teach them how to administer the vaccine, yet this was not the case for rural dwellers. Access to a hospital or healthcare facility was necessary for those populations to effectively immunize. Therefore, even though both rural and urban India were affected by technological barriers related to the eradication of polio because treatment for strands 1 and 3 was not initially available in the country, rural regions struggled with technology more as a result of the transportation costs related to distribution. The main factor that led to the successful eradication was the Indian government and international organizations focusing an equitable amount of effort on vaccination campaigns in both types of areas.

In Nigeria's rural settings, the main barrier to the distribution of the polio vaccine was primarily as a result of cultural and political troubles, while in India's rural settings, they were primarily technological. Although both regions had social issues, India with a gender gap in vaccinations and Nigeria with sterilization rumors, the main obstacles to the distribution in each were vastly different. Studies of India's ability to properly transport the virus show that although child vaccination rates have risen, the lack of technological infrastructure makes it difficult to distribute the OPV to rural and hard-to-reach areas in India. Unlike in Nigeria, horizontal integration of using local knowledge, such as having more local healthcare workers, was not effective in Indian rural communities. Within India's rural regions, the main problem was that cold-chain technology was not developed enough to maintain a potent vaccine. Getting the vaccine to the hospitals in a timely

and efficient manner was difficult in both India and Nigeria. However, in Nigeria, technology was not the barrier. Political strife and religious extremism turned to violence often made it difficult for healthcare distributors and aid groups to get the vaccine to the healthcare workers in hard-to-reach wards. Cultural interactions within the communities that caused resentment of Western medical practices, along with armed militant groups such as Boko Haram, made getting the vaccine on the roads to the communities that needed them extremely difficult. Along with this, the lack of medical infrastructure in these regions made distribution even more difficult.

Limitations

Our research was limited based on the amount of time we had to conduct our research, the restrictions with living in a current pandemic, and many factors regarding the different demographics in Nigeria and India. Since we were limited to only a semester to complete our results and findings in our case study, we were unable to collect as much information and to provide a thorough research on both countries as we desired. Additionally, with our current situation concerning the pandemic, researching a remote setting was a burden in finding information about our topic since we were only able to utilize online resources.

In regard to limitations specifically tailored to Nigeria and India, because we decided to do a case study on urban and rural areas, it was challenging to find quantitative data on specific regions within each country such as the number of cases of polio and the number of people vaccinated in urban and rural settings. Much of the data provided was on the country as a whole rather than segmenting them into different regions. Similarly, differentiating polio eradication in urban and rural settings in Nigeria was difficult due to the limited amount of research available. Most of the research was about northern Nigeria and covered Nigeria as an entire country, overlooking details in urban and rural areas. Since there was minimal research done, we were limited to further analyzing the issue in more well-known areas in Nigeria such as Lagos, one of the most populated cities in Nigeria.

A related issue existed for India—there were isolated studies that focused on the rural and urban centers of certain regions like Lucknow, but the research lacked in investigations regarding the country as a whole. Therefore, we used much of our interpretation based on the research we utilized in this study.

Furthermore, information collected by Nigeria was more based on the cultural and political barriers the country had with polio eradication. Since there was not much information on technology problems with the distribution of the OPV in Nigeria, it was difficult to compare technological issues that happened in Nigeria to India. There were some issues with technology for India—mainly regarding the low efficacy of vaccines that treated strands 1 and 3 of the poliovirus—yet the reason for this is not expanded on in any of the studies we found; thus, we were unable to comment on this disparity with full confidence in our information.

Conclusion

Overall, polio eradication had many barriers and challenges in Nigeria and India because of cultural and technological differences. Thus, it is necessary for global organizations such as the WHO to implement vaccine campaigns more effectively and efficiently by focusing more on horizontal public health interventions. Nigeria and India were both countries that needed stronger infrastructure

and better ways to spread information about the OPV. Nigeria's urban areas were more likely to refuse immunization due to misbeliefs about the vaccine from the mass media and government propaganda. On the other hand, Nigeria's rural areas were more susceptible to poliovirus due to the lack of medical infrastructure and healthcare resources in distributing the OPV. India's condensed urban population puts many residents at risk due to poor sanitation. This population was more likely to receive false information regarding the OPV by word-of-mouth. Communities in rural India had less access to the OPV. Even when vaccines were accessible, a lack of technology in their cold-chain transportation system resulted in rural communities receiving less potent vaccines.

As we face new global pandemics, the lessons of polio eradication campaign to minimize discrepancies in vaccine distribution can be applied to future pandemics and eradications. As we have learned from polio eradication campaign in Nigeria, controlling the narrative on vaccines is critical in ensuring effective distribution. From the challenges faced by India in OPV distribution, we know that going into the next large-scale vaccination campaign, we must ensure that countries are given adequate technology to distribute vaccines safely and effectively. Researchers and scientists must collaborate to develop comprehensive systems for collecting data and distributing vaccines. By establishing these networks, we can overcome the obstacles presented by large-scale vaccination efforts.

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